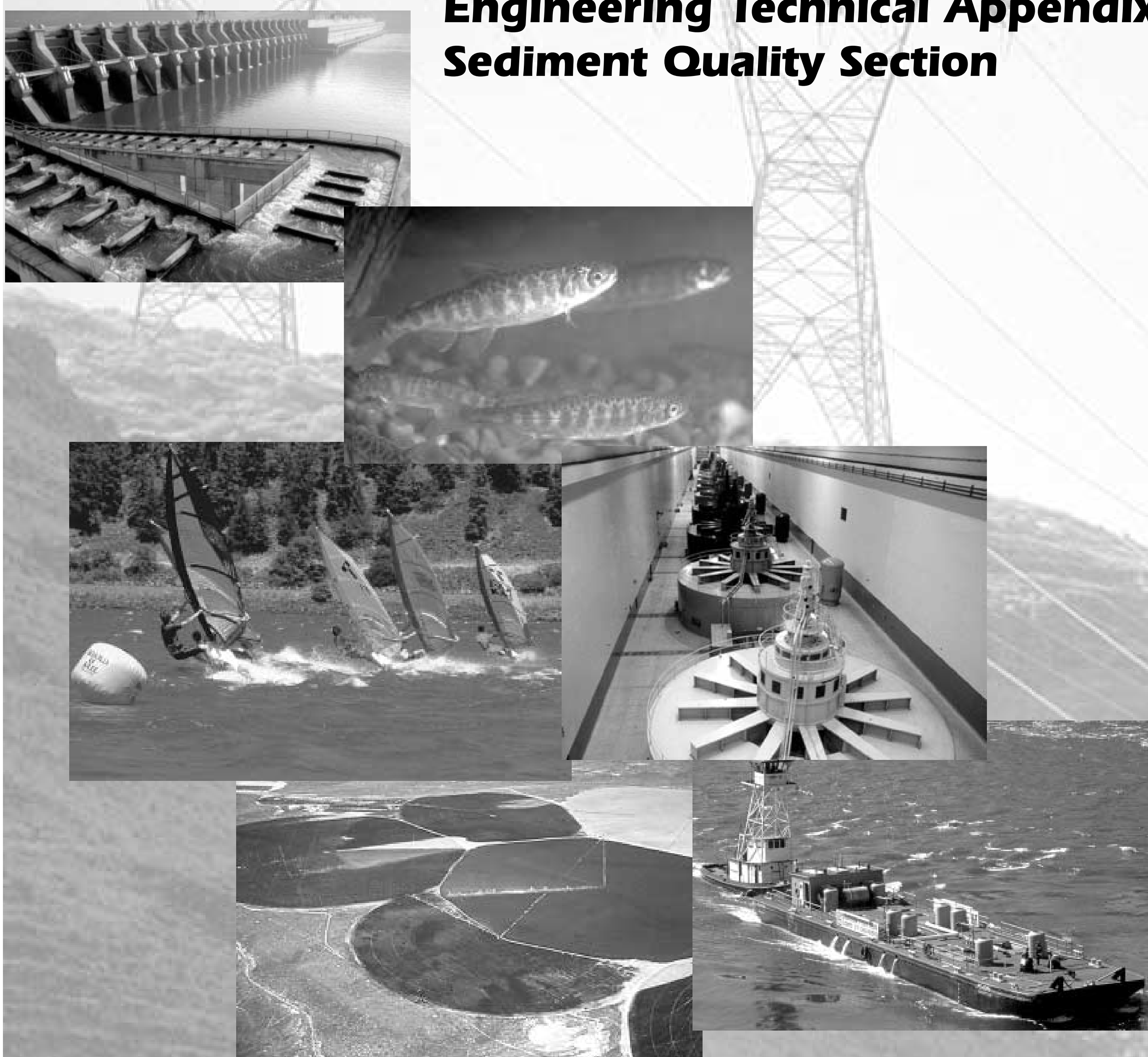
US Army Corps
of Engineers ®
Portland District

Salmon Recovery through John Day Reservoir

John Day Drawdown
Phase I Study

Engineering Technical Appendix
Sediment Quality Section



September 2000

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Section 1. Introduction

This technical appendix section documents the results of the sediment quality evaluation for the John Day Drawdown Phase I Study. This Phase I Study is a reconnaissance-level evaluation of the potential consequences and benefits of the proposed drawdown of the John Day Reservoir. This technical appendix section supplements the main report, which describes more fully the alternatives, purpose, scope, objectives, assumptions, and constraints of the study.

Section 2. Background of the Project

In 1991, the National Marine Fisheries Service (NMFS) proposed that Snake River wild sockeye, spring/summer chinook, and fall chinook salmon be granted “endangered” or “threatened” status under provisions of the Endangered Species Act. Natural resource agencies believe that the drawdown of the 76-mile John Day Reservoir may provide substantial improvements in migration and rearing conditions for juveniles by increasing river velocity, reducing water temperature and dissolved gas, and restoring riverine habitat. It is also speculated that drawdown may improve spawning conditions for adult fall chinook by restoring spawning habitat and the natural flow regimes needed for successful incubation and emergence.

As a result, the NMFS Reasonable and Prudent Alternative Action #5 of its’ Biological Opinion on Operation of the Federal Columbia River Power System (FCRPS), and subsequent reports recommended that USACE investigate the feasibility of lowering John Day Reservoir. In compliance with appropriation conditions, only two alternatives were to be evaluated: reduction of the current water surface elevation 265 to the level of the spillway crest that would vary between elevations 217 and 230, or reduction to natural river level elevation 165. Both alternatives were proposed by NMFS. These two alternatives were then expanded to consider each alternative with 500,000 acre-feet of flood storage and without such storage. Flood storage and hydropower are the current approved authorizations for the John Day project.

Section 3. Description of the Study Area

The Columbia River originates in Canada and flows for 300 miles through eastern Washington to Oregon and continues west to the Pacific Ocean, as shown in Figure 1. The adjoining region is mostly open country, with widely scattered population centers. The climate of the region is semiarid. Agriculture, open space, and large farms are prevalent. Lands adjacent to the reservoir are used to grow grains and other crops. The reach of the Columbia River under consideration in this report extends from John Day Lock and Dam at river mile (RM) 215.6, to McNary Lock and Dam RM 291. The body of water impounded by John Day Dam, Lake Umatilla, is referred to as the John Day Reservoir throughout this report. The John Day is the second longest reservoir on the Columbia River, extending 76 miles upstream to McNary Dam.

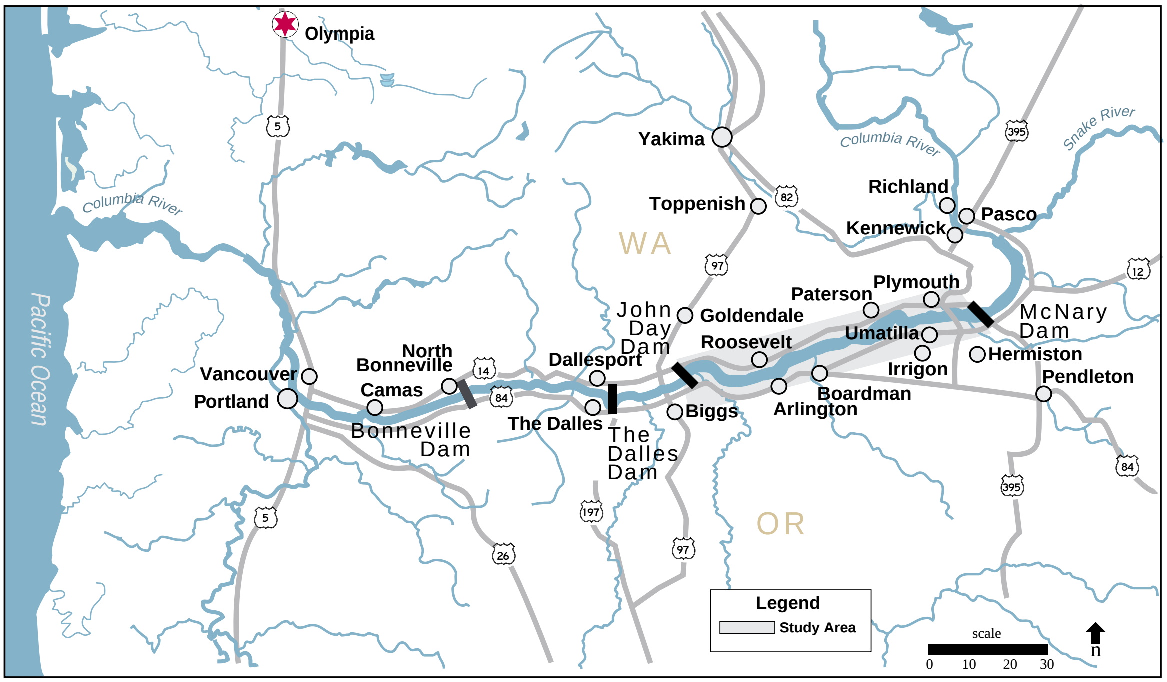

Figure 1. John Day Drawdown Phase 1 Study Area

John Day Dam and Reservoir are part of the Columbia-Snake Inland Waterway. This shallow-draft navigation channel extends 465 miles from the Pacific Ocean at the mouth of the Columbia River to Lewiston, Idaho. The entire channel consists of three segments. The first is the 40-foot-deep water channel for ocean-going vessels that extends for 106 miles from the ocean to Vancouver, Washington. The second is a shallow-draft barge channel that extends from Vancouver to The Dalles, Oregon. Although this section is authorized for dredging to a depth of 27 feet, it is currently maintained at 17 feet. The third section of the channel is authorized and maintained at a depth of 14 feet and extends from The Dalles to Lewiston. In addition to the main navigation channel, channels are dredged to numerous ports and harbors along the river.

The middle Columbia River area is served by a well-developed regional transportation system consisting of highways, railroads, and navigation channels. Railroads and highways parallel the northern and southern shores of the reservoir. Interstate 84 (I-84), a divided multilane highway, runs parallel on the south shore with the Columbia River from Portland, Oregon, to points east. Washington State Route 14 (SR-14) also parallels the Columbia River from Vancouver to McNary Dam on the north shore. Umatilla Bridge at RM 290.5, downstream from McNary Dam, is the only highway bridge linking Oregon and Washington across the Columbia River in the John Day Reservoir.

The study area includes lands directly adjacent to the reservoir as well as those directly and indirectly influenced by the hydrology of the reservoir (e.g., irrigated lands). It includes the reservoir behind the John Day Dam, and adjoining backwaters, embayments, pools, and rivers.

Section 4. Alternatives

The Phase 1 Study includes a preliminary evaluation of the impacts of the drawdown scenarios relative to the “without project condition,” which is defined as the condition that would prevail into the future in the absence of any new federal action at John Day. The four alternatives are summarized below. One of the most important constraints on the alternatives is the requirement to pass fish for river flows up to the 10-year flood flow of 515,000 cfs. Under the four alternatives, John Day Reservoir would be drawn down at a rate of one foot per day. For greater detail, please refer to the main report, *John Day Drawdown Phase 1 Study*, and *John Day Drawdown Phase 1 Study, Engineering Technical Appendix, Structural Alternatives Section*.

4.1. Spillway Drawdown without Flood Control (Alternative 1)

The first drawdown alternative is based on requirements for improved downstream fish passage conditions during both low and flood flow conditions on the Columbia River. The existing 20-bay spillway will be operated differently from current operations, but without any structural modifications. All project inflows will be directly passed through the dam spillway with the spillway gates fully opened in free overflow condition, resulting in a pool elevation that will vary from elevation 217 to 230. Impacts downstream from John Day Dam were not studied.

4.2. Spillway Drawdown with Flood Control (Alternative 2)

The second study alternative is based on requirements for improved downstream fish passage conditions during low flow periods, while maintaining authorized flood control for the John Day Project. The existing 20-bay spillway will be operated differently from current operations, but without any structural modifications. During low flow periods, project inflows will be directly passed through the dam spillway with the spillway gates set in fully open, free overflow condition. During a flood event, however, the spillway gates will be controlled to reduce downstream flood flows based on using 500,000 acre-feet of allocated project storage space. Ponding will occur upstream from the dam. Impacts downstream from John Day Dam were not studied.

4.3. Natural River Drawdown without Flood Control (Alternative 3)

The third study alternative is based on a natural river drawdown for fish passage "without flood control" condition. Natural river conditions pertain to an opening at the John Day Dam that permits acceptable upstream fish passage conditions. The size of the total dam opening must conform to two criteria based on an invert elevation at the dam of 135. The first criterion is that the opening must be sufficiently large to meet maximum allowable stream velocity criteria for sustained swim speed for the weakest salmon species, which is estimated to be 10 feet per second (fps). The second criterion is that fish passage for this opening must correspond to the 10-year annual flood peak (515,000 cfs). This alternative will require extensive modifications to John Day Dam even beyond modification of the 1,228-foot long spillway structure. Impacts downstream from John Day Dam were not studied.

4.4. Natural River Drawdown with Flood Control (Alternative 4)

This fourth study alternative is based on natural river conditions for fish passage and includes the "with flood control" condition. It requires natural fish passage conditions for both upstream and downstream directions at the dam and includes a requirement for full authorized flood control. The calculated width of the total dam opening will correspond to that previously calculated for natural river conditions without flood control (Alternative 3). Impacts downstream from John Day Dam were not studied.

Section 5. Introduction: Tier I Sediment Evaluation

The effects of a drawdown on sediments behind the John Day Dam will be considered from a standpoint of:

- Dredging sediments to maintain the navigational channel
- Effects of erosion
- Exposure of previously submerged sediments
- Effects on potential chemicals of concern associated with surface and sub-surface sediments located near point sources.

The drawdown to spillway and drawdown to natural river conditions will not be considered separately in this evaluation of sediment quality. The contaminates of concern would likely be associated with surface and sub-surface sediments located near point sources and would likely be exposed or move similarly under either scenario.

The amended Clean Water Act (CWA) of 1977 regulates dredging activities and requires sediment quality evaluation that includes testing prior to dredging. Guidelines to implement 40 CFR Part 230, Section 404(b)(1) regulations of the CWA, the national (The *Inland Testing Manual* [ITM]) and the regional (*The Lower Columbia River Management Area Dredge Material Evaluation Framework* [LCRMA-DMEF]) manuals have adopted a tiered testing approach for evaluating dredge material. Guidelines for evaluation of dredge material disposal are the screening levels (SL) contained in the LCRMA-DMEF.

This Phase I Study will involve only a Tier I Study (evaluation of existing data). The short- and long-term effects of a potential drawdown on the sediment-related issues of erosion, dredging, and dredged material discharge into open-water or upland placement must be determined. A complete evaluation of dredge sediment (also required for State Water Quality (401) Certification prior to dredging) would require, at minimum, physical (Tier IIa) and chemical (Tier IIb) sediment sampling and analysis. Bioassay (Tier III) analysis could be required, if chemical screening levels are exceeded in a Tier IIb evaluation.

Section 6. Framework

6.1. Compilation of Existing Information

The contamination potential of the sediment will be evaluated based on transport, physical nature, and its ability to bioaccumulate, or show toxicity above reference levels. The information gathered in this Tier I evaluation will be as complete as possible. Sources of available information will include the following:

- Results of prior physical, chemical, and biological tests, if any.
- Information describing the source of the material in reservoir.
- Existing data contained in files of government agencies, as well as private sources.
- Time since historical sources of contamination.

Other areas to be considered may include: bathymetry, water current patterns, tributary flows, watershed hydrology and land uses, sediment and soil types, and sediment deposition rates.

6.2. Chemical Contamination

The major chemical properties controlling the propensity to bioaccumulate are:

- **Hydrophobicity (fear of water).** These properties will determine if chemical elements or compounds will be readily released into the water column or will remain bound to the sediment if disturbed during possible transport during a drawdown.
- **Aqueous Solubility.** Chemicals such as acids, bases, and salts that speciate (dissociate) as charged entities tend to be water-soluble and those that do not speciate (neutral and nonpolar organic compounds) tend to be insoluble. Solubility increases the uptake of chemicals by organisms, but at the same time favors rapid elimination. However, soluble chemicals generally do not bioaccumulate to a great extent. The soluble free ions of certain heavy metals are exceptional in that they bind with tissues and thus are actively bioaccumulated by organisms.

- **Stability.** For chemicals to bioaccumulate, they must be stable, conservative, and resistant to degradation (although some contaminants degrade to other contaminants, which do bioaccumulate). Organic compounds with structures that protect them from the catalytic action of enzymes or from non-enzymatic hydrolysis tend to bioaccumulate.

Section 7. Existing Data

7.1. Physical Data

The National Marine Fisheries Service (NMFS) collected six sediment stations and submitted them for physical analyses. Each of the six stations was sampled at three depths: 1 meter, 3 meters, and 5 meters. A total of 93 samples are presented from the six stations. With few exceptions, the samples were graded "poorly graded sand with silt" or "silty sand". The average of the samples was 72.2 percent sand, 20.8 percent silt/clay, and 1.4 percent volatile solids with a median grain size of 0.14 mm. A summary of this data is included in Table 1. For station locations see Figure 2.

Table 1
Sediment Physical Analysis Collected by NMFS in 1994 and 1995

93 Samples Averaged	Site Location Description (summary for all samples at this location and depth)	Depth (m)	Mean Grain size (mm)	Gravel (%)	Sand (%)	Silt/clay (%)	Total Fines (%)	Volatile solids (%)
Average	Big Blalock Island	1.00	0.17	0.00	83.77	10.68	16.23	0.82
Average	Big Blalock Island	3.00	0.16	0.02	80.12	17.03	19.85	0.87
Average	Big Blalock Island	5.00	0.17	0.00	83.10	13.03	16.90	0.75
Average	Crow Butte	1.00	0.07	0.00	33.40	59.65	66.60	2.20
Average	Crow Butte	3.00	0.10	4.70	46.95	40.35	48.35	1.60
Average	Crow Butte	5.00	0.06	0.00	50.80	63.45	74.60	3.00
Average	Long Walk Island (downstream site)	1.00	0.17	0.23	91.00	6.32	8.77	1.72
Average	Long Walk Island (downstream site)	3.00	0.08	0.00	54.42	34.62	45.57	2.08
Average	Long Walk Island (downstream site)	5.00	0.08	0.00	55.68	31.58	44.32	2.28
Average	Long Walk Island (upstream site)	1.00	0.09	0.00	60.77	30.03	39.23	1.67
Average	Long Walk Island (upstream site)	3.00	0.08	0.00	56.37	31.92	43.63	2.08
Average	Long Walk Island (upstream site)	5.00	0.15	5.15	74.63	16.23	20.22	1.35
Average	Paterson Slough	1.00	0.12	0.00	67.42	26.68	32.58	0.70
Average	Paterson Slough	3.00	0.13	1.72	79.32	12.38	18.95	0.82
Average	Paterson Slough	5.00	0.12	0.17	74.90	16.80	24.97	0.87
Average	Sand Island	1.00	0.19	0.00	90.10	7.38	9.90	0.62
Average	Sand Island	3.00	0.20	0.00	90.94	7.36	9.06	0.68
Average	Sand Island	5.00	0.23	0.00	92.90	5.80	7.10	2.42

Note: Each entry is a average of the samples taken at that location and depth.

7.2. Port of Morrow Sediment Samples

On March 17, 1999, the USACE collected 11 sediment samples at Messner Cove located at the Port of Morrow in Boardman, Oregon (RM 270). All samples were sent to Sound Analytical Services, Inc. laboratory of Tacoma, Washington, for physical and chemical analyses to include:

- Metals
- Total organic carbon (TOC)
- Pesticides/polychlorinated biphenyls (PCBs)
- Phenols
- Phthalates
- Miscellaneous extractables
- Polynuclear aromatic hydrocarbons (PAHs)

The proposed dredge material from this project was determined to be acceptable for both unconfined in-water and upland disposal. No significant, adverse ecological impacts are expected as a result of sediment toxicity. Guidelines for evaluation of dredge material disposal are the screening levels (SL) contained in the LCRMA-DMEF. See attached Table 2 through Table 6 and Figure 3, Port of Morrow

7.2.1. Drawdown of Granite and Little Goose Reservoirs

The drawdown at Granite and Little Goose Reservoirs provided the following information regarding sediment quality as it relates to a drawdown at John Day Reservoir.

Erosion and Sediment Transport. Increased sediment transport, particularly bed load, was apparent in the confluence area of the Clearwater and Snake Rivers as the head of the reservoir shifted downstream. Tremendous quantities (in excess of 1,000,000 tons during the 15 days of a 28-foot drawdown) were eroded from the confluence area and re-deposited a short distance downstream. The quantity of sediments that could be re-suspended in the water as a result of wind, wave, and rain action on exposed shorelines is unknown. Effects on the ecosystem of resuspension of contaminated sediments by the drawdown are also unknown. Reservoir embankment would have to be protected to the drawdown level to prevent undermining and failure caused by any wind and wave action.

Contaminants. While the level of contaminants from the Granite and Little Goose Reservoirs does not directly relate to the potential of contaminants in John Day sediments, the following notation could apply. If sediment-associated metals concentrations carried by the stream flowing from the Red Wolf Marina as it channeled through the deep sediment deposits, are indicative of levels that would come from exposed mudflats, toxic conditions could be widespread along shorelines following storm events (see oxidation/re-hydration below).

Turbidity. Turbidity increased, although the amount may have been minimal compared to what was possible if rain, wind, and wave action had occurred in amounts more typical of spring weather. The surface turbidity data collected indicated that levels increased at Lower Granite Dam, with this increase first occurring approximately two weeks after the start of the drawdown. Much higher levels were recorded along the shorelines and at stream mouths.

Section 8. Areas of Concern

8.1. Potential Sources of Contamination

8.1.1. Industries

Hanford. Reactor releases of radioactive material occurred from January of 1944 to January 1971. The largest releases occurred during the mid-1950s through the mid-1960s, prior to the startup of John Day Dam.

McNary Dam began operation in 1953. An Oregon State University study concluded that further research is not needed prior to any routine dredging operations in the Columbia River given:

- Low concentrations of the ever diminishing man-made radioactive materials in the sediments behind McNary Dam; and
- Low dose in the most conservative exposure scenario.

John Day Dam began operation in April 1968. This would allow for an approximate 3-year accumulation behind the dam, plus any accumulation prior to pooling of water. The location of McNary Dam between the Hanford Reactors and John Day Reservoir blocked much of the radioactive material from downstream reaches. The addition of John Day Dam to the system did, however, show a reduction in concentrations at points downstream as was demonstrated by a computer model that was used to simulate transport of specific radionuclides from Hanford reactors to Portland, Oregon. The result of the modeling indicated that the five key radioactive materials could be separated into two groups, based on their transport characteristics in the Columbia River.

The first group of radioactive materials with relatively short half-lives—sodium-24, arsenic-76, and nepttunium-239—was sensitive to downstream travel time. The second group—phosphorus-32 and zinc-65—was not affected as much by dam construction because of longer half-lives. Phosphorus-32 has a half-life of 14.3 days, while zinc-65 has a half-life of 245 days. The Oregon Department of Energy states that material released to the river prior to the closure of Hanford would effectively be gone if its half-life was shorter than 2.5 years. A report completed in 1994 by the Washington State Department of Health on radioactivity in Columbia River sediments, concluded that the human-caused radionuclide concentrations found in Columbia River sediments do not pose a significant human health risk. The Bi-State program measured eight radionuclides in a small number of carp and large-scale sucker samples. The level of radioactivity measured in these fish, appear to pose negligible risk to human consumers.

There is a possibility that material with a longer half-life than 2½ years is buried in the sediments behind the dam at John Day Reservoir. While indications are that it does not, it would be prudent to sample for radionuclides in the event of a drawdown at John Day Reservoir.

- **Aluminum reduction plant.** Primary concerns are heavy metals, including nickel, chromium and cadmium. Other concerns include fluoride, sulfide, cyanide, PAHs (in soot from carbon anode).

- **Tributaries and commercial farming.** Primary concerns are ammonia, pesticides, phosphorous, and herbicides.
- **Ports, boat basins and barging**. Primary concerns are low and high-density polynuclear aromatic hydrocarbons (PAHs), cadmium, chromium, copper, mercury, selenium, tin, oil and grease, organotin, and PCBs.
- **Recreation facilities**. Primary concerns are (boat refueling) oil and grease, PAHs (breakdown products of oil).
- **Wood products industry.** Primary concerns are mercury, PAHs and dioxin/furan.
- **Municipal wastewater discharge.** Primary concerns are ammonia, pesticides, chromium, mercury, copper and lead,

In summary, the following are contaminants-of-concern: Nickel, Cadmium, Chromium, Copper, Mercury, Selenium, Tin, ammonia, pesticides, phosphorous, herbicides, low and high-density polynuclear aromatic hydrocarbons (PAHs), oil and grease, Organotin, PCBs, radionuclides and dioxin/furans.

Potential sources of contamination vary with the contaminate of concern. Point source pollution is typical of industrial discharge, where there are known outfalls that have historically discharged into the water pool and associated sediments. Aluminum and wood products industries are prime examples of point source discharge. Non-point source pollution does not have a specific point of origin and often does not have a single entry into the water pool. Stormwater runoff can carry contaminants into the water pool through point source discharge and non-point source discharge. Chemicals used in farming applications, recreation, and commercial boating operations and other contaminates find their way into the water pool by various non-point source accumulations.

8.1.2. Potential Effects of Drawdown on Contaminates of Concern

Oxidation/re-hydration. Sediments under water are in a chemically reduced state (that is, they absorb electrons from the decomposition of organic material). When sediments are exposed to air during an event such as a drawdown, the sediments will begin to dry. With drying, oxidation (especially heavy metals) will occur (that is, give up electrons). This will affect the solubility and availability of these elements as they are re-hydrated or become airborne.

Certain metals such as zinc, cadmium, copper, nickel, and manganese have been found to significantly increase in solubility and can be found in surface runoff water when sediment is re-hydrated after oxidation. Metals in their reduced state are tightly bound to the sediments in an underwater environment. This bond is broken when the sediments oxidize (during drying process) and as a result become much more soluble when reintroduced to water and increased availability for bioaccumulation. The metals are no longer hydrophobic, but remain lipophilic and are bioaccumulated in the fats of organisms.

Volatilization. A 1990 study done at the U.S. Army Waterways Experiment Station on the volatilization of PCBs from sediments exposed to the air may be applicable to this drawdown, if PCBs are discovered to be a contaminate of concern in the study area. (No existing data is available to confirm or deny their presence in the study area). In the study a model was formulated to predict the estimated loss of PCBs in an upland (exposed to the air) situation as compared with an in-water state. The results showed that the mass loss through volatilization of PCBs was four times greater in the sediment exposed to the air than the sediment maintained underwater. This is a potential air quality issue if a significant PCB level is present in the John Day Reservoir sediment. Other compounds have the potential to become volatile as well (i.e. petroleum products).

As the drawdown takes place and possible erosion occurs, during and after the process, from currents, wave action and wind. Contaminated sediments, that are currently below what is now the sediment surface, could be exposed creating a new sediment surface from a source of contamination that was buried with cleaner sediment and was “effectively capped “ in a pre-drawdown state. These conditions might require future monitoring if areas are identified as being contaminated.

Section 9. Future Requirements

9.1. Sampling/Dredging Requirements

Very little physical and chemical data is available on sediment quality in the John Day Reservoir. Without prior sampling and analysis, it is impossible to know what effect potentially contaminated sediment might have during a drawdown or what possible future exposure levels might be. If it is determined that a drawdown is feasible, adequate sediment sampling and analysis would be required to better evaluate the nature and content of the sediment. This would be required to determine not only what effect it might have on water quality and aquatic life during and after a drawdown, but also to evaluate the appropriate disposal of dredge material from the navigational channel and any other potential dredging site. The number of samples necessary would be determined directly by the volume of dredge material removed, correlated with the suspected level of contamination. If dredging is required to maintain the navigational channel in John Day Reservoir, it will be approached like all Clean Water Act dredging projects. The Dredge Material Evaluation Framework for the Lower Columbia River Management Area would be the source of screening levels to evaluate Tier II chemical data derived from sediment samples collected at the shoals or other areas of concern in the navigational channel. For erosion monitoring all confluence areas and any other areas of concern (potential industrial or commercial spills or discharge) would need to be sampled.

Section 10. Conclusions

Very little physical or chemical data is available on sediment quality in the John Day Reservoir area. Without additional data it is impossible to know the potential for release of contaminates of concern during the drawdown by erosion or possible future releases due to physical and chemical breakdown from exposure to atmospheric conditions. If it is determined that a drawdown is feasible, adequate sediment sampling and analysis would be required, prior to the drawdown and possible monitoring during and after the drawdown, to better evaluate the nature and content of the sediment. This evaluation would be required to determine not only what effect it might have on water quality and aquatic life, but also how dredge material would be disposed of in the event dredging is deemed necessary. Sampling would concentrate on all navigational channels (to include boat dock areas) and all tributary confluence areas where most of the erosion would occur. Industrial outfall areas would require sampling and monitoring as well. If contamination above the screening level was discovered as a result of the sampling, biological (Tier III) testing maybe required to determine effects of a release from erosion during drawdown. Highly contaminated areas, if discovered, might require capping and stabilization or dredging prior to a drawdown to prevent a release.

Section 11. References

National Marine Fisheries Service. *July 1995 Sampling Event*, John Day Reservoir Study.

Oregon Department of Energy. July 1997. Fact Sheet: *Radioactivity in Columbia River Sediments*. Oregon State University, Nuclear Engineering department Study. Oregon Department of Energy Nuclear Safety Division, salem, Oregon.

Port of Morrow, Messner Cove, Boardman Oregon. U.S. Army Corps of Engineers, Portland District. March 17, 1999 *Sampling Event and Sediment Evaluation*. Port of Morrow, Messner Cove, Boardman Oregon.

Technical Steering Panel, Department of Ecology, Olympia, WA. April 21, 1994. Summary: *Radiation Dose Estimates from Hanford Radioactive Material Releases to the Air and the Columbia River*.

Tetra Tech. 1992-1993. *Reconnaissance Survey of the Lower Columbia River: Task 1-7*. Prepared for the Columbia River Bi-State Committee. Tetra Tech, Inc., Bellevue, WA.

U. S. Environmental Protection Agency and U. S. Army Corps of Engineers. February 1991. *Evaluation of Dredged Material Proposed for Discharge in Inland and Near Coastal Waters – Testing Manual*, dated (referred to as the "Inland Testing Manual").

U.S. Army Corps of Engineers, Portland District. *March 17, 1999 Sampling Event and Sediment Evaluation*.

U.S. Army Corps of Engineers, Portland District, Seattle District, U.S. Environmental Protection Agency, Region 10, Oregon Department of Environmental Quality, Washington State Department of Natural Resources. April 1998 (draft document). *Dredge Material Evaluation Framework Lower Columbia River Management Area*.

US Army Corps of Engineers, Walla Walla District. December 1993. *1992 Reservoir Drawdown Test Lower Granite and Little Goose Dams*.

Washington State Department of Health. March 1994. *Environmental Radiation Program Special Report,* Radioactivity in Columbia River Sediments and Their health Effects. Olympia, Washington.

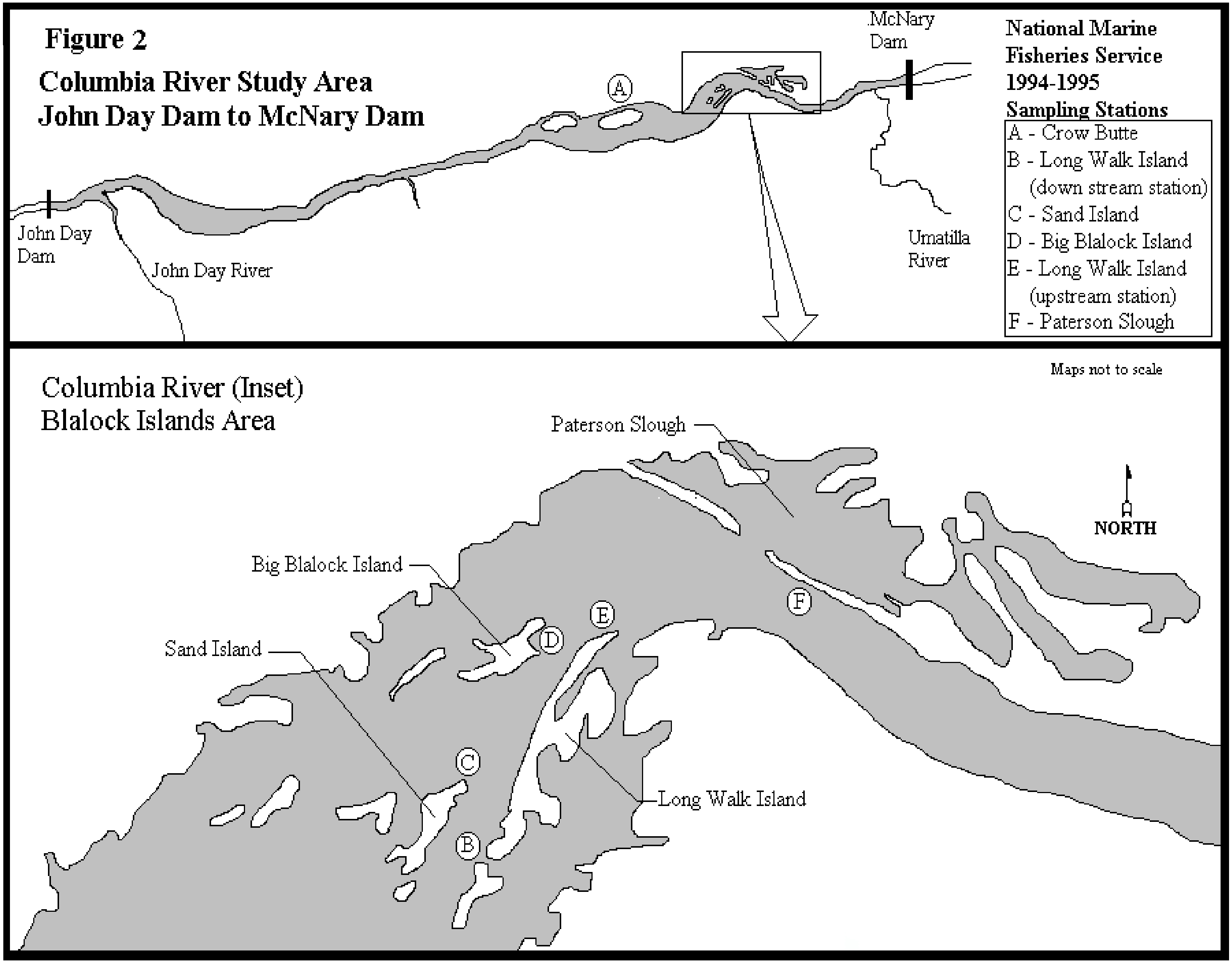
Figure 2
Columbia River Study Area
John Day Dam to McNary Dam
National Marine
Fisheries Service
1994-1995
Sampling Stations
A - Crow Butte
B - Long Walk Island
(down stream station)
C - Sand Island
D - Big Blalock Island
E - Long Walk Island
(upstream station)
F - Paterson Slough
McNary
Dam
John Day
Dam
John Day River
Umatilla
River
A
Columbia River (Inset)
Blalock Islands Area
Maps not to scale
NORTH
Paterson Slough
Big Blalock Island
Sand Island
Long Walk Island
B
C
D
E
F

Table 2
Physical Analytical

	Grain Size (mm)		Percent			
Sample I.D.	**Median**	**Mean**	**Gravel**	**Sand**	**Silt/Clay**	**Volatile solids**
PM-GC-01	0.09	0.13	0.7	62.2	37.0	3.2
PM-BC-02	0.18	0.06	0.0	94.7	5.3	1.5
PM-BC-03P	0.15	0.08	0.0	89.9	10.1	1.8
PM-BC-04	0.06	0.06	0.0	47.7	52.3	2.9
PM-BC-05	0.12	0.12	0.0	71.8	28.2	2.3
PM-BC-06	0.12	0.10	0.0	75.0	25.0	2.9
PM-BC-07	0.21	0.14	0.0	97.5	2.5	1.0
PM-BC-08	0.25	0.17	0.0	96.9	3.1	4.8
PM-BC-09	0.04	0.09	0.0	87.2	12.8	3.8
PM-BC-10	0.08	0.05	0.0	61.7	38.3	3.0
PM-BC-11	0.26	0.19	2.0	81.2	16.8	1.8
PM-BC-11 (Lab Dup)	0.19	0.16	0.6	83.7	15.8	2.8
Mean	0.15	0.11	0.3	79.1	20.6	2.7
Minimum	0.06	0.05	0.0	47.7	2.5	1.0
Maximum	0.26	0.19	2.0	97.5	52.3	4.8

Port of Morrow. Sampled March 17, 1999

Table 3
Inorganic Metals and TOCs

Sample I.D.	As	Sb	Cd	Cu	Pb	Hg	Ni	Ag	Zn	TOC
	mg/kg (ppm)									
PM-GC-01	<22	<65	**0.98**	**12**	<11	<.11	**6.5**	<2.1	**72**	**10000**
PM-BC-02	<20	<59	**0.61**	**9.5**	**16**	<0.095	**6.2**	<1.9	**93**	**1600**
PM-BC-03C	<21	<61	**0.74**	**13**	**250**	<.01	**7.7**	<2.0	**41**	**3000**
PM-BC-04	<22	<64	**0.96**	**17**	<11	<0.11	**13**	<2.1	**100**	**7300**
PM-BC-05	<21	<61	<0.5	**15**	<10	<0.11	**9.9**	<1.9	**91**	**5200**
PM-BC-06	<21	<61	<0.5	**15**	**10**	<0.1	**6.2**	<1.9	**91**	**8400**
PM-BC-07	<19	**62**	<1.1	**7.7**	<9	<0.11	**6.6**	**2.2**	**44**	**750**
PM-BC-08	<18	<53	<1.1	**8**	<8.7	<0.11	<3.9	<1.7	**38**	**480**
PM-BC-09	<20	**65**	<0.48	**9.6**	<9.7	<0.11	**4.4**	<1.9	**69**	**2400**
PM-BC-10	<22	<63	**1.0**	**15**	<11	**0.1**	**9.8**	<2.0	**110**	**6000**
PM-BC-11	<19	<53	<1.1	**10**	**12**	<0.097	**9.6**	<1.7	**70**	**3200**
Screening level (SL)	57	150	5.1	390	450	0.41	140	6.1	410	
Mean	<20	11.5	0.39	11.98	26.2	0.009	7.3	0.2	74.5	
Maximum	<22	65	1	17	250	0.1	13	2.2	110	

Symbol (<) = Non-detect at the value listed (Method Detection Limit)

Port of Morrow. Sampled March 17, 1999.

Table 4
Pesticides/PCBs, Phenols, Phthalates, Chlorinated Organic Compounds and Extractables

Sample I.D.	Phenols			Phthalates						Extractables	
	ug/kg (ppb)										
	Phenol	Pentachloro phenol	3-&4-Methyl phenol	Dimethyl phthalate	bis(2-Ethylbenzyl phthalate	Butylbenzylph thalate	Di-n-octyl phthalate	Diethyl phthalate	Di-n-butyl phthalate	Benzoic acid	Dibenzofuran
PM-GC-01	<3.1	<1.8	<1.6	**10.0**	**29.0**	**6.7**	<1.7	**64.0**	**65.0**	<6.9	<2.8
PM-BC-02	<3.1	<1.8	<1.6	**12.0**	**27.0**	**3.2**	<1.7	<4.5	**14.0**	<6.9	<2.8
PM-BC-03C	<3.1	<1.8	<1.6	**79.0**	**19.0**	**3.0**	**5.8**	<4.5	**11.0**	<6.9	<2.8
PM-BC-04	<3.1	**11.0**	**5.8**	**54.0**	**19.0**	<1.5	<1.7	<4.5	**18.0**	<6.9	<2.8
PM-BC-05	**5.4**	<1.8	**13.0**	**120.0**	**21.0**	<1.5	<1.7	<4.5	**15.0**	<6.9	**5.6**
PM-BC-06	<3.1	<1.8	<1.6	**110.0**	**23.0**	<1.5	**7.1**	<4.5	**20.0**	**14.0**	<2.8
PM-BC-07	<3.1	<1.8	<1.6	**13.0**	**15.0**	<1.5	<1.7	<4.5	**12.0**	<6.9	<2.8
PM-BC-08	<3.1	**29.0**	<1.6	**27.0**	**16.0**	<1.5	<1.7	<4.5	**9.4**	<6.9	<2.8
PM-BC-09	<3.1	<1.8	<1.6	**18.0**	**17.0**	**4.0**	**2.7**	<4.5	**15.0**	<6.9	<2.8
PM-BC-10	<3.1	<1.8	<1.6	**39.0**	**22.0**	<1.5	<1.7	<4.5	**12.0**	**13.0**	<2.8
PM-BC-11	<3.1	<1.8	<1.6	**7.3**	**21.0**	**9.7**	<1.7	<4.5	**19.0**	**11.0**	<2.8
Screening level (SL)	420.0	400.0	670.0	1400.0	8300.0	1200.0	6200.0	970.0	8300.0	650.0	540.0
Mean	0.5	3.6	1.7	120.0	20.8	2.4	1.4	5.8	19.1	3.5	0.5
Maximum	5.4	29.0	12.0	37.9	29.0	9.7	5.8	64.0	65.0	14.0	5.6

PCBs = Non-detect <18.0 (SL = 130)

Pesticides = Non-detect <3.6 (SL = 10, Total DDT = 6.9)

Symbol (<) = Non-detect at the value listed (Method Detection Limit)

Port of Morrow. Sampled March 17, 1999

Table 5
Polynuclear Aromatic Hydrocarbons (PAHs); Low Molecular Weight Analytes ug/kg (ppb)

Sample I.D.	Acenapththene	Acenaphthylene	Anthracene	Fluorene	2-Methylnapthalene	Naphthalene	Phenanthrene	Total Low PAHs
PM-GC-01	**2.7**	<2.4	<2.2	<2.3	**3.5**	**2.7**	<1.8	**8.9**
PM-BC-02	<1.9	<2.4	<2.2	<2.3	<2.2	<1.9	<1.8	<2.3
PM-BC-03C	<1.9	<2.4	<2.2	<2.3	**3.3**	<1.9	**2.8**	**6.1**
PM-BC-04	<1.9	<2.4	<2.2	<2.3	**10.0**	**4.3**	**11.0**	**25.3**
PM-BC-05	<1.9	<2.4	<2.2	<2.3	**14.0**	**8.6**	**8.9**	**31.5**
PM-BC-06	<1.9	<2.4	<2.2	<2.3	**8.5**	**6.8**	**7.7**	**23.0**
PM-BC-07	**2.7**	<2.4	<2.2	<2.3	**4.9**	<1.9	<1.8	**4.9**
PM-BC-08	<1.9	<2.4	<2.2	<2.3	**8.7**	<1.9	**2.7**	**14.1**
PM-BC-09	<1.9	<2.4	<2.2	<2.3	**5.2**	<1.9	<1.8	**5.2**
PM-BC-10	<1.9	<2.4	<2.2	<2.3	**4.2**	<1.9	**4.2**	**8.4**
PM-BC-11	<1.9	<2.4	<2.2	<2.3	<2.2	<1.9	<1.8	<2.4
Screening level	500.0	560.0	960.0	540.0	670.0	2100.0	1500.0	29000.0
Mean	0.5	<2.4	<2.2	<2.3	5.7	1.8	3.4	11.1
Maximum	2.7	<2.4	<2.2	<2.3	14.0	8.6	11.0	31.5

Symbol (<) = Non-detect at the value listed (Method Detection Limit)

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Table 6
Polynuclear Aromatic Hydrocarbons (PAHs); High Molecular Weight Analytes ug/kg (ppb)

Sample I.D.	Benz(a)anthracene	Benzo(b)fluroanthene	Benzo(k)fluroanthene	Benzo(g,h,i)perylene	Chrysene	Pyrene	Benzo(a)pyrene	Dibenz(a,h)anthracene	Indeno(1,2,3-cd)pyrene	Fluoranthene	Total High PAHs
PM-GC-01	<1.4	<2.1	<1.9	<1.5	<2.4	**5.5**	<1.5	<1.4	<1.8	<2.2	**5.5**
PM-BC-02	<1.4	<2.1	<1.9	<1.5	<2.4	<2.2	<1.5	<1.4	<1.8	<2.2	<2.4
PM-BC-03C	<1.4	<2.1	<1.9	<1.5	<2.4	<2.2	<1.5	<1.4	<1.8	<2.2	**3.5**
PM-BC-04	<1.4	**3.5**	<1.9	<1.5	**3.5**	**4.1**	<1.5	<1.4	<1.8	**5.8**	**16.9**
PM-BC-05	**3.5**	<2.1	<1.9	<1.5	**3.5**	**4.2**	<1.5	<1.4	<1.8	**6.7**	**14.4**
PM-BC-06	<1.4	**3.7**	<1.9	<1.5	<2.4	**5.4**	<1.5	<1.4	<1.8	**7.4**	**12.8**
PM-BC-07	<1.4	<2.1	<1.9	<1.5	<2.4	<2.2	<1.5	<1.4	<1.8	<2.2	<2.4
PM-BC-08	<1.4	<2.1	<1.9	<1.5	<2.4	<2.2	<1.5	<1.4	<1.8	<2.2	<2.4
PM-BC-09	<1.4	<2.1	<1.9	<1.5	<2.4	<2.2	<1.5	<1.4	<1.8	<2.2	<2.4
PM-BC-10	<1.4	<2.1	<1.9	<1.5	<2.4	**6.2**	<1.5	<1.4	<1.8	**5.3**	**11.5**
PM-BC-11	<1.4	<2.1	<1.9	<1.5	<2.4	<2.2	<1.5	<1.4	<1.8	<2.2	<2.4
Screening level	1300.0	3200.0		670.0	1400.0	2600.0	1600.0	230.0	600.0	1700.0	12000.0
Mean	0.3	0.3	<1.9	<1.5	0.6	2.3	<1.5	<1.4	<1.8	2.3	5.9
Maximum	3.5	3.5	<1.9	<1.5	3.5	6.2	<1.5	<1.4	<1.8	7.4	16.9

Symbol (<) = Non-detect at the value listed (Method Detection Limit)

Port of Morrow. Sampled March 17, 1999

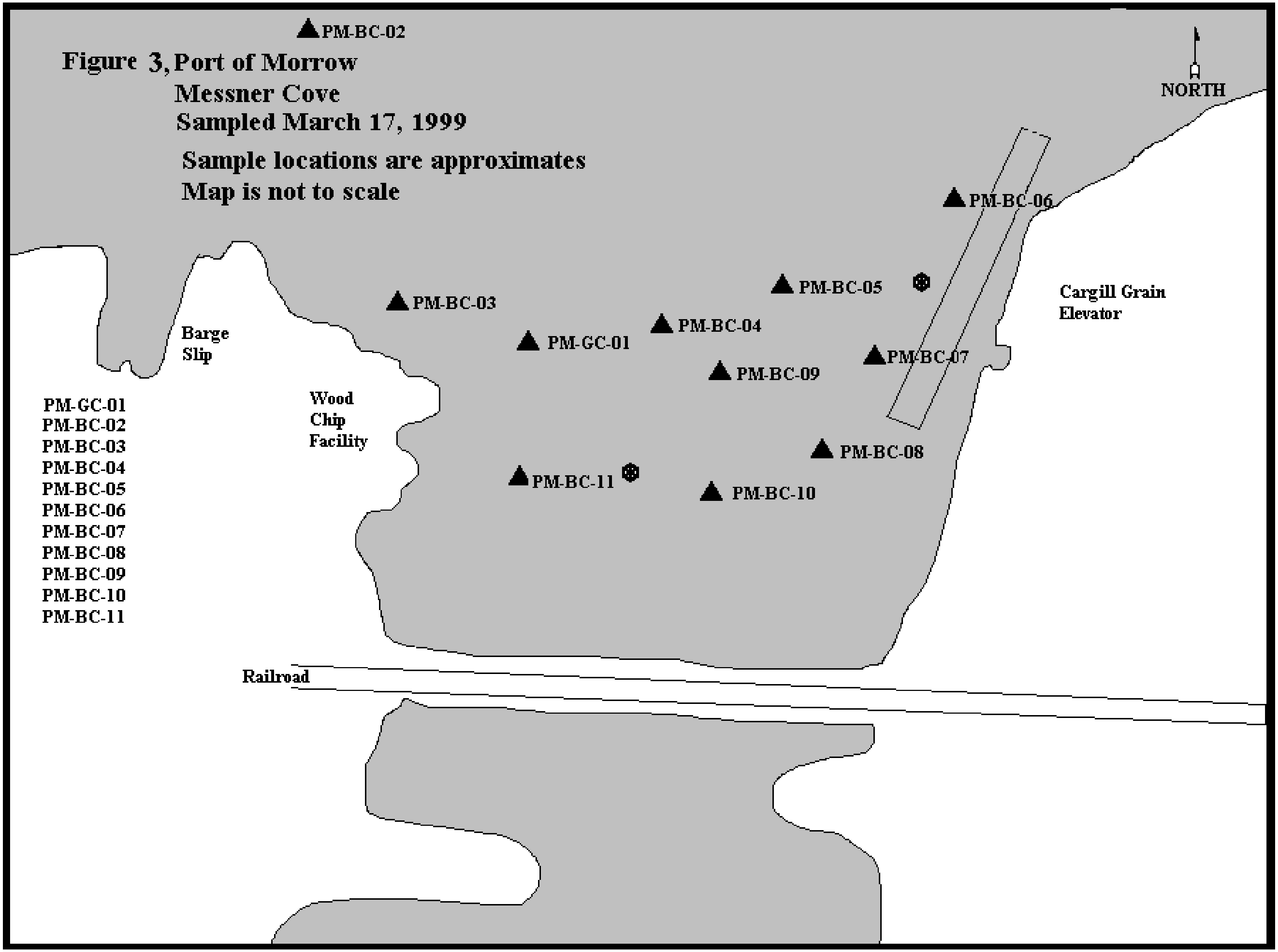

Figure 3, Port of Morrow
Messner Cove
Sampled March 17, 1999